**MDE Product Development Team**
**FY13 August Monthly Report**
**Submitted 16 September 2013**

With contributions from **Geoff DiMego** and **Mary Hart** (NCEP/EMC);
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**Jordan Powers** (NCAR/MMM); **Roy Rasmussen and Greg Thompson** (NCAR/RAL);
and **Ming Xue** (CAPS).

*(Compiled and edited by S. Benjamin and B. Johnson)*

## Executive Summary

### Task 1: Improve turbulence guidance from NWP forecasts

- RAPv2 continues in parallel testing on WCOSS; new comparisons between RAPv1-operational and RAPv2 parallel for 1h and 6h forecasts show improvement from RAPv2 for wind, temperature and humidity forecasts at nearly all altitudes.
- New parallel RAP test with 0.75 weights for ensemble background error covariance (vs. variation) in hybrid assimilation gave further improvement to wind forecasts.
- RAPv2 summer 2013 configuration implementation continues to run smoothly on Jet (Boulder, RAP primary cycle) and Zeus (Fairmont WV) supercomputers and initializing experimental HRRR.
- RAPv2 implementation at NCEP is still currently scheduled for Q1 FY14 (December 2013).
- Three real-time parallel RAP cycles (with extensive verification of each) running on Zeus NOAA research supercomputer located in Fairmont, WV to evaluate further likely enhancements to RAP data assimilation / model system for spring 2014 code freeze.
- NCEP making progress on NAM and NAM-nest

### Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Modification to real-time ESRL HRRR (and RAP) to correct error in coupling of land surface model to boundary layer scheme that was producing slightly high dew point bias for certain situations.
- Retrospective evaluation of combined 13-km RAP / 3-km HRRR radar reflectivity assimilation impact and work toward evaluation of 3-km HRRR radial velocity assimilation impact.
- Continuing evaluation of HRRR forecast skill for convective systems indicating improvements over 2012, especially for short lead-time.
- HRRR infrastructure installed on NCEP WCOSS computer and testing underway with implementation tentatively scheduled for Q2 FY14 (Mar 2014), following the RAPv2 implementation now planned for Q1 FY14 (Dec 13).
- Continued work on 3-km radial velocity assimilation.
- Completion of milestone for prototype 15-min-frequency Real-Time Mesoscale Analyses (RTMA) using HRRR background fields including production of grids.
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### Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Same updated physics configuration now running in both RAPv2 at GSD and in parallel cycle on WCOSS machine at NCEP (MYNN boundary-layer scheme (Olson version, 9-level PBL, updated Thompson microphysics, others)
- Important fix made to canopy evaporation in RUC LSM when MYNN boundary-layer scheme is used.
- Further improvements to MYNN PBL scheme are producing improved near-surface winds, planned for late 2013 implementation into ESRL RAP and HRRR

### Task 4: Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

- Real-time, frozen RAPv2/HRRR system running successfully with gridded field dissemination, real-time web display of graphics and verification of many forecast fields.
- Ongoing monitoring of RAPv2/HRRR system with regards to reliability (including joint reliability with Jet – Zeus failover) and forecast performance.
- HRRR “failover” capability to use feed from Zeus instead of Jet during Jet downtime is working; enhancements necessary to make Zeus completely independent of Jet will come in July.
- Examination of enhanced verification of HRRR convective forecasts, including VIL and echo-top.

**Task 1: Improve turbulence guidance from NWP forecasts**

*Improving turbulence forecast quality involves efforts to improve initial conditions for the RAP and NAM (and HRRR and NAM Nest models) and to improve the models (WRF-Advanced Research WRF (ARW)-RAP and NOAA Environmental Modeling System (NEMS)- Nonhydrostatic Multi-scale Model – B (NMMB)).*

Tasks will include:

- Continuing evaluation of RAPv2 toward early 2014 implementation at NCEP, incorporating changes developed in 2012 and early 2013
- Development of RAPv3 toward 2014 implementation at ESRL and subsequent implementation at NCEP
- Collaborating on developing and testing best approaches for use of hybrid/EnKF/3DVAR data assimilation within common GSI coding structure.

**ESRL**

*Regarding the operational NCEP RAP*
August was the first month with the NCEP operational suite running entirely on the new Weather and Climate Operational Computing System (WCOSS). The operational RAP (RAPv1) ran without any technical problems, including post processing, during the month.

*Progress toward RAPv2 implementation at NCEP*

- RAPv2 implementation is currently planned for 17 December 2013.

- In late August a significant bug was quashed in the RUC LSM as a result of revisiting the cause of the very high latent heat fluxes in cloudy regions that was noted in the July report. The culprit was excessive canopy water evaporation when the RUC LSM is coupled with the MYNN boundary layer and surface-layer scheme. This problem only occurred in regions of recent precipitation, and its correction removed a moist bias and often-excessive surface-based CAPE values in such regions. This fix, along with a much less significant adjustment to the computation of moisture availability, are now in the EMC RAPv2 code as well as in the RAP-primary and dev1 cycles at GSD.

- Summer and winter 30-day retrospective experiments are underway on the Zeus computer using the same code as is now running in the EMC RAPv2 parallel cycle. The dates of these retros are ~26 Jan – ~26 Feb 2013, and 15 May through 15 June 2013. We anticipate these will be complete before the end of September. In addition, intensive real-time comparisons of the now identical GSD RAP-primary and EMC parallel (EMC RAPv2) are ongoing.

- Grids from the EMC RAPv2 parallel cycle are being verified at GSD as of 2 September. Fig. 1 shows improved performance of the EMC RAPv2 parallel relative to the operational RAPv1 for this two-week period. This is evident for both 1 and 6-h forecasts for nearly all altitudes from the surface to 100mb, and for wind, temperature and relative humidity, as anticipated from earlier comparisons of the GSD RAP-primary cycle with the operational RAPv1 shown in earlier reports.

- On 14 August, Stan Benjamin, with help from Geoff Manikin (NCEP/EMC), gave a new update on RAPv2 and HRRR science status to NCEP management at a WCOSS Science Quarterly review meeting – ppt available here **http://ruc.noaa.gov/pdf/EMC_RAPV2_Upgrade-HRRR-final-14aug2013.pdf**. This ppt gives a good summary of the differences between RAPv2 and RAPv1.

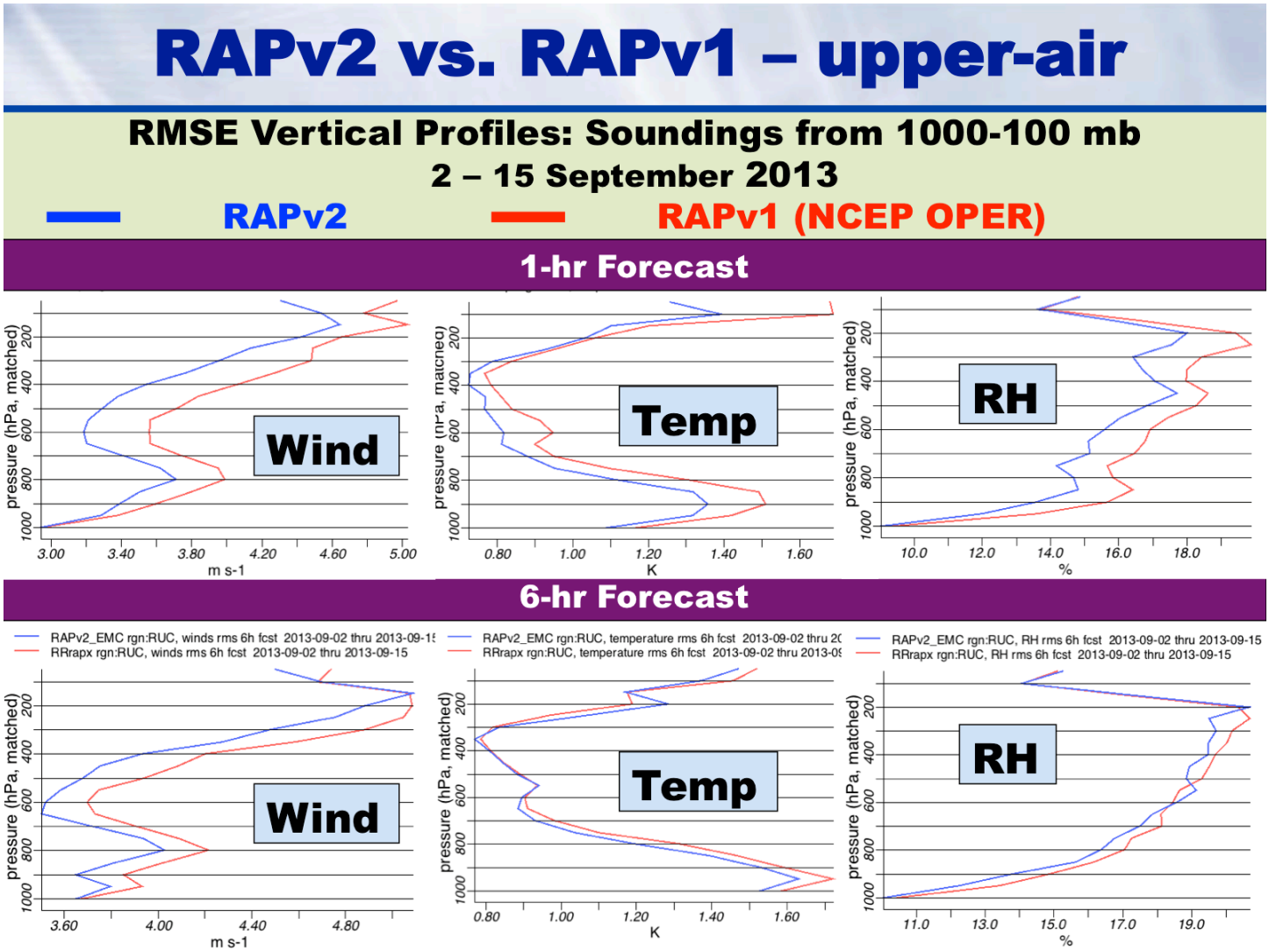


***Figure 1. Verification of RAPv2 (ESRL) vs. RAPv1 (NCEP operational) forecasts vs. rawinsonde observations for 1h and 6h duration for wind, RH, and temperature. Line further to left shows smaller error and more accurate forecast.***

*RAPV3 data assimilation testing (reported in July 2013)*

- Ming Hu ran a new 1-week parallel warm-season test with a modification to the hybrid ensemble/variational data assimilation, now using a 0.75/0.25 weighting of ensemble vs. fixed background error covariance instead of the current 0.5/0.5 weighting. This result gave improved upper-level wind forecasts, and if this result is also found in a later cold-season test, this modification would be included in future versions of the RAP at ESRL (implemented in Jan-Mar 2014), where it will also improve the ESRL HRRR. It also will be included in the subsequent (can be called "RAPv3") version at NCEP.
- Another parallel test was run with mesonet observations added (Patrick Hofmann). Results showed slightly better surface wind forecasts and slightly poorer 2m temp forecasts. A new study will next test a further mesonet assimilation impact test but now using a much improved observation use list (developed by Bill Moninger) and modified GSI code to use this modified use list (by Xue Wei), to be run again by Patrick Hofmann.
- Patrick Hofmann made additional parallel tests for full-column cloud building using the GOES CLAVR-X effective cloud amount. (Still better results in avoiding the previous mid-tropospheric moist bias that plagued previous full-column satellite-based cloud building). This change appears to be ready for RAPv3.

*RAPv3 model testing*

- Parallel testing continues toward improving the MYNN boundary-layer scheme. Now that the canopy-water evaporation bug has been fixed, efforts are now directed toward reducing a warm and dry bias during daytime under clear skies (see Task 3).

- Investigations are underway to better specify lake surface temperatures after an email from NWS Western Region noting that small lakes in the western US are too cold. (Tanya Smirnova, others)
- Tanya Smirnova continues to investigate changes to the RUC LSM relating to surface roughness length over snow (see Task 3).
- A new precipitation-type verification is being tested with retrospective and real-time RAP and HRRR output. (Bill Moninger)

Other activities, some noted more fully under other tasks, also were undertaken:

- Retrospective testing for both RAP and HRRR of the impacts of proprietary in situ tower wind data and other special data continued under funding from the DOE Wind Forecast Improvement Project.
- Discussions with EMC are underway concerning the best procedure to ensure that proprietary wind tower and nacelle wind measurements are available to the operational RAP and NAM now that WCOSS has come online.
- Biweekly telecons between GSD and the Storm Prediction Center of NCEP continue to be very beneficial. The purpose of these telecons is to obtain feedback from SPC on RAP (RAPv2 from GSD as well as the operational v1) and GSD HRRR-primary performance, to give SPC opportunity to comment on our ongoing RAP and HRRR development work, and to inform SPC of planned Jet and Zeus computer downtimes.

**NCEP**

Testing of Version 2 of the Rapid Refresh continued in August, with the EMC real-time parallel still running. A code bug leading to excessive canopy evaporation was discovered and fixed, and the corrected version is now running. ESRL is running retrospective runs with the corrected code to verify that the change has no unintended consequences. The mid-December implementation date remains on track. (Geoff Manikin)

A kick-off implementation meeting with NCEP Central Operations for the Q1 FY2104 RTMA upgrade package was held. Formatting the various components of the upgrade package to conform to the required vertical directory structure continues. Some of the shortcomings of the RTMA analysis over complex terrain and ways to address them have been discussed with team members from the Sandy Supplemental Blender Project. New reject and accept lists for the RTMA were computed using innovation statistics from May through July 2013. A database has been setup to compare outputs from the operational, parallel, and HRRR-based RTMAs. (Manuel Pondeca, Steve Levine)

At end of July, a few cycles of the operational NARRE-TL failed on WCOSS. After troubleshooting, the cause was found to be a memory fault in the case when the time-lagged files were out of order on the WCOSS. This condition has not repeated but a code fix was developed and this fix will be included in the next RAP upgrade bundle. As requested by the Aviation Weather Center, 10 extra stations will be added to the station list for BUFR output for RAP, NAM, each SREF member, and the SREF ensemble mean. (Binbin Zhou, Jun Du, Geoff Manikin, Eric Rogers)

A failed radar data processing job on WCOSS was checked and the cause was found to be a memory leak in the raw data decoder. A fix was developed and submitted for implementation. A new QC step was added to the radar QC package to examine test patterns in the raw data. Work was begun to merge reflectivity assimilation codes and scripts onto the NCEP WCOSS. (Shun Liu)

The operational processing of METOP-B IASI data began in early August. It was found that because of the amount of data, the regional analysis run time increased significantly when the observations were turned on. Since METOP-B data were not turned on automatically, there was no impact on the operational NDAS. Work was completed to adapt part of the parallel scripts to allow testing of analysis changes on WCOSS. The system was then used to test the latest upgraded GSI code before implementing that GSI in the official NAM parallels. In preparation for the next global implementation at higher resolution, NDAS hybrid analysis was tested with T575 global ensemble inputs. The sigma files were about five times larger, and the run times increased by 40%. The solution to the timing problem was to use MPI-IO to speed up reading the global ensemble files. Part of the SIGIO library was included in an experimental GSI where different MPI processors directly read the different components to save resources. Using this experimental GSI code saved about 40% of current run time; roughly the same run time as the current system. This code is expected to merge into the GSI for the next global implementation. (Wan-Shu Wu)

**CAPS**

In the last month, we replaced 13-km dual-resolution hybrid background (deterministic) forecasts with interpolated 40 km ensemble mean forecasts in all cycles (hereafter HybridRP). The forecasting results were compared with those of hybrid1WCtl (40 km 1-way hybrid experiment), hybridIntrp13km (pure 13-km forecasts launched from interpolated 40-km Hybrid1WCtl hybrid analyses) and Hybrid1WD (13-km forecasts from dual-resolution analyses without background forecast replacement). Relative humidity from HybridRP significant out-performed those from Hybrid1WCtl, hybridIntrp13KM and Hybrid1WD for the 3-hour forecasts, and wind forecasts from HybridRP were also slightly improved. The precipitation verifications show that HybridRP outperforms Hybrid1WCtl, HybirdIntrp13km and Hybrid1WD for 0.1, 1.25 and 2.5 mm/h after 5 hours, indicating the benefit of higher resolution analyses on the 13 km grid using dual resolution for precipitation forecasts. Hybrid1WD outperforms HybridRP for 1.25 and 2.5 mm/h in the first 5 hours because of the benefit from the 13 km higher-resolution deterministic forecasts. At the same time, we also compared the forecasts from GSI (40 km GSI 3DVAR experiment), GSIIntrp13KM (13-km forecasts launched form interpolated 40 km GSI 3DVAR analyses) and GSI13KM (pure 13 km GSI 3DVAR experiment). RMSEs against sounding data from GSI, GSIIntrp13km and GSI13KM were comparable. As in the case of dual-resolution hybrid, precipitation from GSI13KM for 0.1 and 0.25 mm/h is clearly better. The general conclusion is that high-resolution analyses on the 13 km grid, either with dual-resolution hybrid, or 13-km GSI, improves precipitation forecasts, but do not necessarily improve sounding verification. In fact, 13 km forecasts starting from interpolated 40-km analyses tend to fair worse for sounding verifications for short-range forecasts.

**Additional information on RAP-related tasks**

**ESRL**

GSD continues to make pgrb and bgrb files from the ESRL/GSD RAP-primary (RAPv2) real-time 1-h cycle available from its FTP site for users in NWS and other labs)**.**

**NCEP**

NCEP maintained real-time availability of SAV and AHP guidance to all vendors from the operational hourly RAP on pressure surfaces via the NWS Family of Services (FOS) data feed and via the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (EMC&NCO)

NCEP maintained real-time availability of full resolution gridded data from the operational RAP runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/rap/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.rap_CY.00 through MT.rap_CY.23. This includes hourly BUFR soundings and output grids, which undergo no interpolation. Both sites now contain only grids in GRIB2 format **http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml.** Gridded RAP and NARRE [-TL] fields are available on **NOMADS** for the CONUS domain on 13 km grid #130 and the Alaska domain on 11.25 km grid #242. RAP fields are also available for the larger North American domain on 32 km grid #221. A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov** . (EMC&NCO)

**Verification of RAP**

ESRL's verification of the RAP is available from **http://ruc.noaa.gov/stats**. NCEP maintained its capability and provided access to routine verifications of the operational RAP analyses and forecasts. These include grid-to-station verifications versus rawinsonde, surface, aircraft, Profiler, and VAD data computed periodically at NCEP and accessible via NCEP's Mesoscale Modeling Branch website: **http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html** .

| Deliverables | Delivery Schedule |
|---|---|
| **Task 1 – Improve turbulence guidance from NWP forecasts** | |
| a. Finalize code for RAPv2 for implementation at NCEP (ESRL, NCEP)<br>• Vigorous effort leading complete package with extensive improvements, summary at: http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2013.pdf | Mar 2013<br>**COMPLETE** |
| b. Complete the testing of the 40/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data (GSD, CAPS)<br>• Initial work completed by CAPS, testing of further enhancements to system. GSD testing and inclusion in RAPv2 of hybrid system with full observational data, using GFS ensemble data. Milestones exceed. | Mar 2013<br>**COMPLETE** |
| d. Report on early version of RAPv3 primary cycle at GSD with physics enhancements for initialization of the HRRR. (ESRL) | Dec 2013 |
| e. Report on the optimal configurations for including satellite data in the 40/13 km dual-resolution hybrid system to ensure overall positive impacts of the data (NCEP, ESRL) | Dec 2013 |
| f. Finalize RAP version to initialize experimental HRRR for 2014 real-time use toward operational HRRR (ESRL) | Mar 2014 |
| g. Deliver progress report on development of NARRE (NCEP, ESRL) | Mar 2014 |
| h. Deliver progress report on ensemble/hybrid data assimilation for use in NARRE (ESRL, NCEP) | Mar 2014 |
| i. Subject to NCEP Directors' approval, upgrades to observation processing &/or quality control and/or GSI and/or NMMB systems become Operational at NCEP. (NCEP) | Mar 2014 |
| j. Incorporate physics and dynamics improvements from the user community, GSD, and NCEP into WRF for use in the Rapid Refresh system. (NCAR-MMM) | Mar 2014 |

**Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE**

**GSD**

In late August a modification was made to the HRRR WRF-ARW model formulation to correct an issue with the LSM that was causing excessive canopy water evaporation when the LSM is coupled with the MYNN PBL and surface-layer scheme. This problem was noticed in the RAPv2 and only occurred in regions of recent precipitation, and its correction removed a moist bias and often-excessive surface-based CAPE values in such regions. This fix, along with a much less significant adjustment to the computation of moisture availability, are now in the EMC RAPv2 code as well as in the RAP-primary and dev1 cycles at GSD and the HRRR (which uses the same WRF-ARW configuration for these modules).

Major work toward a carefully controlled comprehensive evaluation of the 2013 RAP and HRRR in a retrospective environment continues by Eric James in collaboration with Curtis Alexander and Ming Hu. A 2-week spin-up period has been completed (during the first half of May 2013) and a control run for the last two weeks of May 2013 is underway. In conjunction with these RAP retrospective experiments, Steve Weygandt has conducted an assessment of the combined RAP/HRRR radar data assimilation impact. His results confirm the positive benefits on HRRR forecasts for the

first several hours from the 13km radar assimilation and the additional benefit from the 3-km HRRR radar assimilation for the first few hours, with a maximum benefit during the overnight into early morning hours. Additional work is ongoing to evaluate the benefit from 3-km radar radial velocity assimilation in the HRRR.

Patrick Hofmann successfully tested a prototype 15-min HRRR-based RTMA analysis, creating grids and graphics. This project involved significant work to 1) write data processing code/scripts to covert continuously updated ESRL NetCDF observation files to the GSI-required prepBUFR format with the appropriate 15-min window of data, 2) modify GSI to allow sub-hourly data processing and analysis generation capabilities, create required scripts and runtime environment to create prototype test. Sample plots of surface temperature and wind from the 15-min. HRRR-based RTMA analysis is shown in Fig. 1.

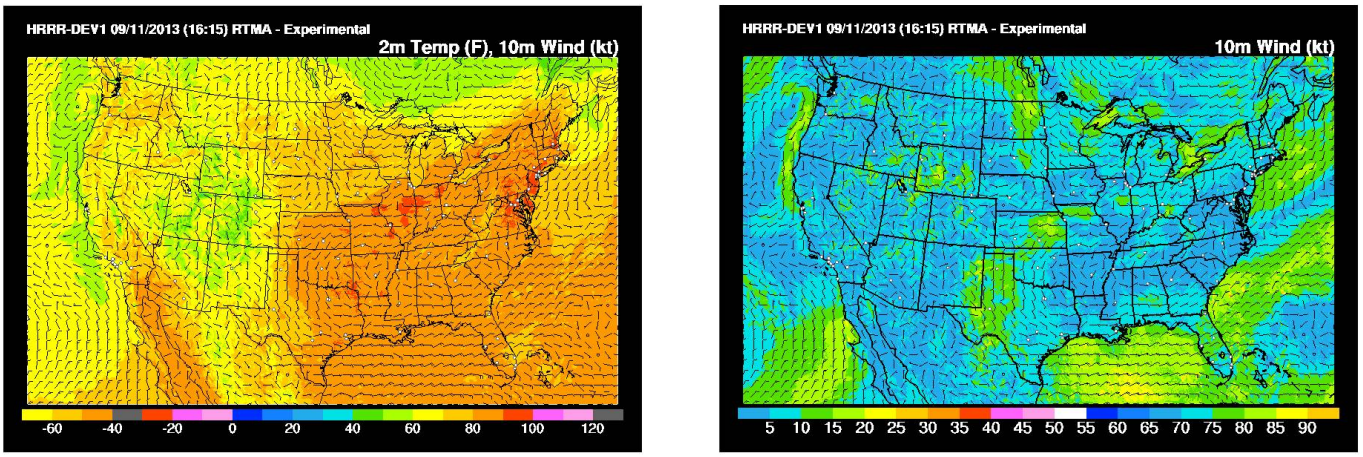


**Figure 2.** ***Sample graphics from prototype 15-min HRRR-based RTMA analysis for 1615 UTC 11 Sept.: 2 m temperature (left) and 10 m wind (right).***

**NCEP**

NCEP EMC and NCO conducted a planning exercise of what the modeling suite might look like on the Weather and Climate Operational Supercomputing System (WCOSS) Phase 1 (2013-2015) and Phase 2 (2015-2018). The size of the latter would be enhanced by the Sandy Supplemental funds. This plan incorporated ESRL/GSD along with all other contributors to the NCEP Production suite. NWS Director Louis Uccellini was briefed 28 March. While tentative, these plans called for an initial HRRR implementation on 65 nodes on Phase 1, and a HRRR Ensemble (HRRRE), combining multiple runs with configurations of both WRF-ARW and NMMB, on Phase 2. A sizable bank of computing (65 nodes) was dedicated on Phase 2 to advanced data assimilation for the convective allowing scales of the HRRRE, likely involving a 4-dimensional version of the current GSI-hybrid-EnKF.

| **Deliverables** | **Delivery Schedule** |
|---|---|
| **Task 2 – Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE** | |
| a. Report on initial tests of 3-km 15-min RTMA cloud / surface analysis for use in frontal diagnostics, CI assessment and other near-surface assessments (ESRL, NCEP)<br><br>• *Good progress toward 3km RTMA and RUA surface and cloud analyses*<br>• *Successful initial tests summarized in report:* | Feb 2013<br><br>COMPLETE |

| Deliverables | Delivery Schedule |
|---|---|
| http://ruc.noaa.gov/pdf/GSD_RTMA_report.pdf | |
| b. Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for 2013 real-time use (ESRL)<br><br>• *Extensive set of enhancements in place and running in real-time experimental GSD RAPv2 / HRRR system* | Mar 2013<br><br>**COMPLETE** |
| c. Provide preliminary 15-min RTMA surface analyses as experimental improved basis for frontal diagnostics and other diagnostics from surface analyses (ESRL, NCEP)<br><br>**Prototype HRRR-based 15-min RTMA analysis completed with sample grids and graphics.** | Aug 2013<br><br>**COMPLETE** |
| d. Report on computing resource status on NCEP Central Computing System, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR (NCEP, ESRL)<br><br>See above discussion concerning ~2014 implementation and Task 4 | **June 2013**<br><br>**COMPLETE** |
| e. Complete FY13 internal assessment with revised 3-km HRRR running every hour (ESRL)<br><br>**Assessment ongoing with good results seen for 2013 HRRR in objective and subjective verification** | Sept 2013 |
| f. Provide revised 15-min RTMA surface analyses as primary basis for frontal diagnostics and other diagnostics from surface analyses for real-time use in 2014 (ESRL, NCEP) | Feb 2014 |
| g. Finalize all changes to the HRRR for real-time use in 2014 (ESRL) | Mar 2014 |

**Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE**

**GSD**

The RAP physical parameterization configuration resulting from test and evaluation of physics options during the late 2012 – early 2013 period and described in previous reports is also what is being tested now on the NCEP WCOSS computer in preparation for the RAPv2 implementation scheduled for FY2013Q2:

- New 9-level configuration of the RUC land-surface model (RUC LSM) with fix to canopy evaporation when the MYNN surface layer is used.
- Mellor-Yamada-Nakanishi-Niino (MYNN) planetary-boundary- and surface-layer scheme (modified considerably by Joe Olson) in place of the Mellor-Yamada-Janjic (MYJ) scheme used in RAPv1.
- Continue use of the Grell G3 scheme from WRFv3.2.1.
- Continue use of the Goddard short wave and RRTM long-wave radiation schemes.
- Use WRFv3.4.1 version of the Thompson microphysics.

As noted under Task 1, a significant bug in the canopy water evaporation was found in late August. As it turns out, the units of the canopy-water evaporation (aka latent heat flux from the canopy) are needed in different units with the MYNN surface layer as opposed to that of the MYJ, so this bug only affects latent heat flux when the MYNN surface layer is used. This removed the moist bias we had been seeing in cloudy areas in RAPv2 and that was noted in the July MDE report.

Forecasters in the National Weather Service Western Region have called our attention to unexpected forecast wind patterns by the HRRR in the vicinity of small lakes in the western US this summer. This has been traced to the manner in which the high-resolution sea-surface temperature analysis performed by NCEP is interpolated to estimate water temperatures for these lakes… taking the temperature of the nearest large body of water. Anecdotal evidence suggests that this results in assigning a much too cold-water temperature to these lakes, which are often shallow and hence warm by mid-summer. This leads to spuriously strong lake-breeze circulations in daytime. Different approaches to address this problem are under investigation.

With the RAPv2 now in parallel testing at NCEP, focus in physics development is shifting toward upgrades for RAPv3. We anticipate work in all aspects of the physics that will likely result significant changes for RAPv3:

- Possible replacement of RRTM long wave and Goddard short wave by the long and short wave versions of RRTMG. In addition to provision for attenuation of solar radiation by aerosol, RRTMG has a more rigorous accounting for the attenuation of solar radiation by ice and snow recently developed by Greg Thompson. Consideration may also be given to better accounting for attenuation of solar radiation by boundary layer driven clouds through prediction of a cloud fraction (this work leveraged from other agency funding and in collaboration with NCAR).
- Further testing of candidate LSM changes including 1) treatment of albedo in situations of partial snow cover, which itself must be parameterized, 2) reduction of surface roughness in areas of snow cover over scrubland and cropland (earlier testing on this was mostly done with the MYJ PBL and surface layers) 3) further consideration of the representation of snow melt in low-level warm-advection conditions typical of spring.
- Further upgrades to the MYNN surface and boundary layer schemes.
- Further testing of the Grell-Freitas convection for possible inclusion in RAPv3.
- In the next few months, testing of changes to the Thompson microphysics for WRFv3.5.1. We anticipate these will mainly impact higher rainfall rates and therefore may be of importance for the HRRR configuration in 2014.
- Likely beginning early in FY2014, but pending on NCAR preparing the code for transfer to GSD (see item a. under table of Task 3 deliverables below), test and evaluation of the new aerosol-aware microphysics from NCAR. This is a potential major change and will require careful evaluation.

Some of this testing for RAPv3 is already underway. Joe Olson has introduced some minor changes to the MYNN that decrease entrainment into the daytime mixed layer from above as part of an effort to mitigate the aforementioned daytime warm and dry bias. These are only active when there is a mixed layer. They are being tested in the RAP-dev2 cycle currently. Despite these temperature issues low-level wind forecasts in RAPv2 continue to show substantial improvement over the operational RAP, due to use of the MYNN PBL and surface layer schemes. So, we do not anticipate experimenting with other PBL and surface-layer schemes for RAPv3.

**GSD requests deferral of Deliverable 3.c (Request for Change for RAPv2 physics) from May to Sept 2013.**
As described earlier under Task 1 efforts, testing is now underway for RAPv2 on the new NCEP WCOSS computer. But this date was inadvertently set too early.

**NCEP**

To assist GSD in fitting HRRR into the allotted computer resource (65 nodes) on WCOSS, NCEP is asking an IBM Applications Analyst to look at and hopefully speed up the WRF-ARW as run in the HRRR. (DiMego)

**NCAR/RAL**

CURRENT EFFORTS: During the month of August, NCAR-RAL completed the writing of a journal paper on the aerosol sensitivity experiments of the large winter cyclone from 31Jan to 02Feb 2011. This manuscript was circulated within NCAR for internal review before officially submitting to Journal Atmos. Sci. NCAR-RAL is now in the process of making code changes needed for proper input and boundary condition data from the global monthly climatological aerosol data to final usage in WRF. The original NetCDF format GOCART climate data has been recomputed to a form needed by the microphysics scheme and output into a WPS-intermediate format so it can more readily be included into WRF by users.

FUTURE EFFORTS: NCAR-RAL continues to coordinate with NCAR-MMM WRF code developers to ensure the simplest transfer of the new aerosol code into a future WRF release (v3.6). Once integrated into the WRF code repository, NCAR-RAL will assist NOAA-GSD to adopt/utilize the new scheme.

PROBLEMS/ISSUES ENCOUNTERED: Currently we do not foresee any delays, but integration of the aerosol-aware microphysics scheme depends on availability of NOAA-GSD and NCAR-RAL personnel.

INTERFACE WITH OTHER ORGANIZATIONS:
Alison Nugent (PhD student) and Ron Smith, Yale University
Yaitza Luna (PhD student), Howard University

**NCAR/MMM**

**Deliver a WRF Users' Workshop and WRF Tutorial for the User Community**

As reported previously, NCAR organized the 14th WRF Users' Workshop June 24–28 (**http://www.mmm.ucar.edu/events/2013_wrfusers/index.php**). This given at NCAR's Center Green facility in Boulder, and the attendance was 220. NCAR gathered participant feedback and will use that in the planning of next year's event.

NCAR also organized and delivered a WRF tutorial at its Foothills Lab on July 15–26. This included a basic WRF tutorial, a WRFDA tutorial, a WRF-Chem tutorial, and a WRF regional climate tutorial. Approximately 60 participated. The tutorial is described at: **http://www.mmm.ucar.edu/events/tutorial_137/index.php**.

PLANNED EFFORTS: None.

UPDATES TO SCHEDULE: None

NCAR began preparation of WRF minor release Version 3.5.1. This will primarily contain bugfixes and minor updates. The release is planned for September.

Jimy Dudhia if NCAR/MMM added a few important changes to the WRF repository. These addressed modifications to code for surface and LSM processes: (i) an allowance of sea-ice fraction to use with the QNSE-EDMF PBL (code from Matt Tastula, Univ. of Southern Florida); (ii) a fix for the NoahMP LSM using with the MYJ and QNSE PBL schemes; and (iii) a RUC LSM fix for latent heat flux (from Tanya Smirnova, NOAA).

Dudhia worked with Ming Chen (NCAR/MMM) to test and fix the NoahMP LSM for an issue found in its use with the MYJ PBL scheme in which the MYJ produced too-little cloud in ocean areas. The source of the problem was the absence of the CHKLOWQ argument that had been removed for V3.5, and the fix was to reinstate this, but with a fixed value of 1.0. The CHKLOWQ functionality is limited to Noah and was part of NCEP's operational suite with MYJ. NCEP set this to zero for saturated lowest-level conditions, but this is not needed.

In work with WRF-Solar, Dudhia collaborated with Jose Ruiz-Arias (Univ. Jaen, Spain) on improving surface solar outputs. Repository additions have now implemented the first phase of his improvements
that: (i) allow direct and diffuse surface solar outputs from all radiation options, (ii) improve the solar position computation to include the equation of time (annual orbital cycle local solar time correction), and (iii) add a swint_opt namelist option to interpolate SWDOWN between radiation steps (rather than using step changes, which smoothes the surface flux behavior). Further work will address clear-sky aerosols for addition to the repository, as well as high-frequency surface outputs that can account for cloud changes.

Dudhia continued work on a purely horizontal diffusion approach (diff_opt=2) that would reduce in magnitude in steep coordinate regions. This could be a way to use the method in complex terrain, as it currently is not stable in such conditions. Travis Wilson (UCLA) has tested a version, and he and Dudhia will be modifying the method for further testing.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP will continue through FY13Q4.

UPDATES TO SCHEDULE: None

| Deliverables | Delivery Schedule |
|---|---|
| **Task 3 – Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE** | **Delivery Schedule** |
| a. Complete initial evaluation of aerosol-aware microphysics in RAP real-time cycling at GSD for its suitability as part of the RAPv3 prototype for 2014 NCEP implementation (NCAR-RAL, ESRL) | Delayed until Feb 2014 |
| b. Final model physics code transfer complete to EMC for Rapid Refresh 2 upgrade change package to be implemented at NCEP by spring 2014 (ESRL, NCEP)<br>• Freeze of model physics code for March 2013 version of RAP at ESRL allows this milestone to be met. | Mar 2013<br>**COMPLETE** |
| c. Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v2 software to NCO (NCEP, ESRL) | May 2013<br>**Deferred to Sept 2013** |
| d. Transfer upgraded coupled aerosol-microphysics scheme into a test version of HRRR (NCAR-MMM, ESRL) | Dec 2013 |
| f. Finalize microphysics changes and other physics changes to improve icing forecasts for ESRL version of RAP and HRRR for 2014 real-time use (ESRL) | Mar 2014 |
| g. Report summary of icing probability skill measures by quarter for the year. (NCEP) | Mar 2014 |

**Task 4: Develop convection-ATM-specific improvements for guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA**

**Task 4 – Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL)**

*Current*:

An improved retrieval in GSI of snow hydrometeors from radar reflectivity observations has been tested and will be implemented in the ESRL RAP and HRRR later this year. This improved retrieval will reduce the amount of snow mixing ratio that is specified in very cold regions of the model where low reflectivities are observed. The snow mixing ratio retrieval will be limited to a maximum value of 3 g/kg to avoid excessive snowfall in the model forecast. This change in the retrieval will continue to permit a reversible diagnostic of model reflectivity in WRF from the hydrometeors that both matches the observed reflectivity and is consistent with the model microphysics scheme (Thompson) used in the RAP and HRRR.

A format change in the radar reflectivity observational data feed received at ESRL from NSSL for use in the ESRL RAP and HRRR radar reflectivity data assimilation and forecast verification was implemented on 30-31 July. Work was completed in August to adapt the ESRL RAP and HRRR data assimilation pre-processing code and forecast verification code to the new format. The radar-based verification code was updated for real-time verification of RAP and HRRR forecasts. The radar data assimilation pre-processing code has now been tested in a parallel real-time RAP run and implementation in the primary ESRL RAP and HRRR is planned for September. An increase in the precision of the observational VIL feed from NSSL was also implemented to ensure adequate precision for verification of winter

precipitation. A feed of legacy format radar data was established to maintain continuity of radar data assimilation in the ESRL RAP and HRRR until the new format can be used.

A new retrospective period from 15-31 May 2013 has been established to begin evaluation of model and data assimilation changes for the 2014 version of the ESRL RAP and HRRR. A control run for the retrospective period is underway using the 2013 ESRL RAP and HRRR versions but also include~~s~~ an adjustment in soil temperature and moisture and a correction in the RUC land surface model to remove unrealistic surface evaporation flux in areas of precipitation that ~~was~~ were not available during the real-time runs in early May 2013.

*Planned*:
We plan to complete the transition to the new format radar reflectivity data feed for both the ESRL RAP and HRRR radar data assimilation.

Evaluation of ESRL RAP and HRRR model and data assimilation changes will be conduced using the 15-31 May 2013 retrospective period. An evaluation of the latest Thompson microphysics scheme in WRF-ARW version 3.5.1 will be conducted including testing and calibration of the associated reflectivity, VIL and echo top diagnostics.

**Task 4 – Assess HRRR reliability and provide monthly reporting (ESRL)**

**HRRR Reliability for 0-8 Hour VIL/Echo Tops for August 2013**

**Jet**
All runs: 96.2%
**3 or more consecutive missed runs: 98.4% (most meaningful for CoSPA)**
6 or more consecutive missed runs: 99.6%
5 outages of at least 3 hrs. or longer
1 outage of at least 6 hrs. or longer

**Zeus**
All runs: 91.4%
**3 or more consecutive missed runs: 95.3% (most meaningful for CoSPA)**
6 or more consecutive missed runs: 97.4%
6 outages of at least 3 hrs. or longer
5 outages of at least 6 hrs. or longer

**Combined (Jet or Zeus)**
All runs: 98.7%
**3 or more consecutive missed runs: 99.3% (most meaningful for CoSPA)**
6 or more consecutive missed runs: 100.0%
2 outages of at least 3 hrs. or longer
0 outage of at least 6 hrs. or longer

**Task 4 – Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014**

Tracy Smith is continuing to analyze results from an initial 5-day retrospective test run to evaluate the impact of the assimilation of GOES-CI cloud-top cooling rate data on RAP convection forecasts. She has computed various skill-scores and assesses individual case periods. Results continue to show slight improvement in short-convective forecasts (slightly improved CSI associated with better POD, but slightly higher FAR as well). Results (+3h forecast images and CSI scores vs. lead-time for a sample RAP forecast are shown in Fig. 3). Work is continuing to re-run the RAP retrospective with an adjusted heating rate and to test direct assimilation of the GOES-CI fields in the HRRR.

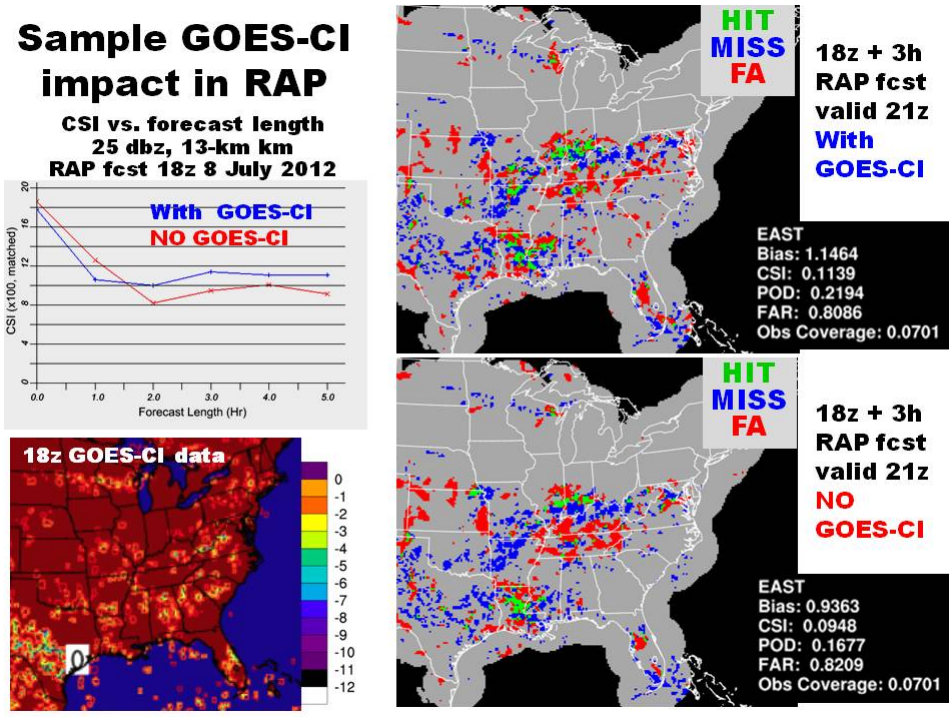


**Figure 3.** ***Right – Hit/Miss/False Alarm depiction from RAP +3h forecast reflectivity with and without GOES-CI (Satcast) cloud-top cooling rate assimilation for sample case (1800 UTC 8 July 2012). Left CSI skill scores vs. forecast length for this case + plots of assimilated GOES-CI data.***

**Task 4 – Interact with CoSPA (or other) program partner labs and the FAA**

Team (ESRL/GSD, NCAR/RAL, and MIT/LL) telecons and e-mail correspondence have and will continue to occur to discuss issues related to the HRRR reliability including scheduled outage periods during the CoSPA 2013 season. An informal discussion with MIT/LL on assessing the HRRR from an air traffic control perspective; took place on August 27. This meeting provided an opportunity to discuss possible collaboration on convective weather avoidance polygons including the potential for feedback on the evolution of the size distribution of forecasted convective structures in the HRRR.

| Deliverables | Delivery Schedule |
|---|---|
| **Task 4 – Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA** | |
| Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL)<br>• Code for revised echo-top / reflectivity diagnostics with revised microphysics implemented in GSD real-time HRRR. | Mar 2013<br>**COMPLETE** |
| Conduct baseline testing of the early 2013 HRRR version (ESRL)<br>• Baseline testing of 2013 HRRR version completed as part of code preparation for freeze. Summary of skill score improvements being prepared. | Mar 2013<br>**COMPLETE** |

| | |
|---|---|
| Report on evaluation of new microphysics scheme and associated echo-top and reflectivity diagnostics in ESRL/GSD RAP and HRRR (ESRL)<br>• *Preliminary evaluation completed and summarized in report:*<br>**http://ruc.noaa.gov/pdf/GSD_reflectivity_report.pdf** | Mar 2013<br>**COMPLETE** |
| Assess HRRR reliability and provide monthly reporting (ESRL)<br>Reliability statistics are being reported each month | *Apr 2013*<br>**COMPLETE** *(ongoing)* |
| Report on evaluation of revised WRFv3.4 microphysics for RAP/HRRR for its effects on echo-top and reflectivity in ESRL RAP/HRRR (ESRL) | Mar 2014 |
| Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2014 real-time use of HRRR (ESRL) | Mar 2014 |
| Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014 (ESRL)<br>**Evaluation of preliminary results** | Mar 2014<br>**Good progress** |
| Report on 2014 baseline testing of the HRRR (ESRL) | Mar 2014 |